IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of Steven M. Powell, *et al.*	)	
Serial No. 10/694,617	)	Before the Board of Patent Appeals and Interferences
Filed: October 27, 2003	)	
For: Tubular Polymeric Composites for Tubing and Hose Constructions	)	March 05, 2007
Examiner Patrick F. Brinson Group Art Unit 3754	)	Cleveland, Ohio 44124-4141

HONORABLE COMMISSIONER FOR PATENTS
ALEXANDRIA, VA 22313-1450

APPELLANTS' AMENDED BRIEF ON APPEAL

Responsive to the Notification of Non-Complaint Appeal Brief mailed December 28, 2006, submitted herewith in accordance with 37 C.F.R. § 1.192 is Appellants' Amended Brief on Appeal. Reversal of the Examiner's rejection of the appealed claims and the allowance thereof is respectfully requested.

The Commissioner is authorized to charge the requisite fee or to credit any overpayment to Deposit Account No. 16-0325 (a separate deposit account authorization is enclosed).

Respectfully submitted,

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CERTIFICATE OF TRANSMISSION

I hereby certify that this correspondence is being transmitted to the United States Patent and Trademark Office by EFS on March 05, 2007.

John A. Molnar, Jr.

I. REAL PARTY IN INTEREST

Parker-Hannifin Corporation, an Ohio corporation having an address at 6035 Parkland Boulevard, Cleveland, Ohio 44124-4141, owns all right, title and interest in the above-identified application by virtue of an Assignment recorded September 12, 2002, on Reel 013082, Frame 0478.

II. RELATED APPEALS AND INTERFERENCES

No other appeals or interferences are known to Appellants, Appellants' legal representative, or assignee, which would directly affect or be directly affected by, or have a bearing on the Board's decision in the pending appeal.

III. STATUS OF CLAIMS

i. Claims originally filed: 1-43.
ii. Claims canceled: none.
iii. Claims added: none.
iv. Claims withdrawn from consideration but not canceled: 1-35 and 41-43.
v. Claims allowed: none.
vi. Claims rejected: 36 and 37.
vii. Claims objected to: 38-40.
viii. Claims pending: 36-40.
ix. Claims on appeal: 36-40.

IV. STATUS OF AMENDMENTS

Forty-three (43) claims were submitted in the subject application as originally filed.

A first Office action was mailed on June 02, 2005, imposing a restriction requirement as between claims 1-35, 36-39 [*sic*], and 40-43. Claims 36-40 were elected in a response dated June 24, 2005.

A first Office action on the merits October 05, 2005, was mailed on November 30, 2001, rejecting claims 36 and 37, objecting to claims 38-40, and withdrawing claims 1-35 and 41-43 as

being drawn to non-elected inventions. Responsive to that action, an amendment was filed on March 14, 2006, amending claims 38 and 40 to correct certain informalities.

A second and final Office action, mailed June 16, 2006, maintained the rejection of claims 36 and 37, and the objections to claims 38-40 as being dependent on a rejected base claim, but otherwise as constituting allowable subject matter. This appeal followed.

The claims pending in the application therefore are 36-40, all of which are subject to the instant appeal. A clean copy of these claims is annexed hereto.

V. SUMMARY OF CLAIMED SUBJECT MATTER

There is one (1) independent claim involved in this appeal: claim 36. Claim 36 is directed to a tubular polymeric composite such as for use as or in hoses and tubing. [*See* Specification, at page 1, ll. 6-8]. As claimed, such composite includes a first layer formed of a chemically-resistant polyamide material, and a second layer bonded directly to the first layer. [page 4, ll. 4-15]. The second layer is formed of a less-expense, more general purpose polyurethane material having a relatively high durometer to provide strength and flexibility to the construction. [page 9, l. 3, bridging page 10, l. 3].

VI. GROUNDS OF REJECTION TO BE REVIEWED ON APPEAL

Did the Examiner err in finally rejecting claims 36 and 37 under 35 U.S.C. § 103(a) as being unpatentable over Douchet (U.S. Patent No. 5,706,865), in view of Gray *et al.* (U.S. Patent No. 4,380,252)?

VII. ARGUMENT

Grouping of Claims.

For the purpose of the present appeal only, it is Applicants-Appellants' intention that the claims be grouped as follows:

i. Independent claims 36 is considered to be patentable independent of the other claims;

ii. Claim 37 is considered to stand or fall with independent claim 36 from which it depends; and

iii. Claims 38-40 are considered to be patentable independently of the other claims, but as standing or falling together.

The Examiner erred in finally rejecting claims 36 and 37 under 35 U.S.C. §103(a) as being unpatentable over Douchet, in view of Gray et al.

Claims 36 and 37 stand finally rejected under 35 U.S.C. § 103(a) as being unpatentable over unpatentable over Douchet (U.S. Patent No. 5,706,865), in view of Gray *et al.* (U.S. Patent No. 4,380,252). Copies of the Douchet and Gray *et al* references are attached hereto as, respectively, Items 1 and 2 of the Evidence Appendix.

Douchet has been cited as disclosing a multi-layer hose having a second layer of a hot melt polyurethane bonded to a first layer of a polyamide. Gray *et al.* has been cited as disclosing a multi-layer hose including an inner layer formed of a polyurethane material having a hardness of from about 75 Shore A to about 63 Shore D. The examiner is of the opinion that it would have been obvious to modify the polyurethane of Douchet to have a durometer of at least 63 Shore D as suggest by Gray *et al.* in order to harden and stiffen the hose to accept reinforcement without substantial deformation of the tube.

However, it is well-settled that obviousness cannot be established by combining the teachings of the prior art to produce the claimed invention absent some teaching, suggestion, or incentive supporting the combination. *In re Geiger*, 2 U.S.P.Q.2d 1276, 1278 (Fed. Cir. 1987), *citing ACS Hospital Systems, Inc. v. Montefiore Hospital*, 221 U.S.P.Q. 929, 933 (Fed. Cir. 1987), *See also Gambro Lundia AB v. Baxter Healthcare Corp.*, 110 F.3d 1573, 1579, 42 USPQ2d 1378, 1383 (Fed. Cir. 1997) (noting that the "absence of such a suggestion to combine is dispositive in an obviousness determination"). The Federal Circuit has cautioned that the suggestion to combine requirement is a safeguard against the use of hindsight combinations to negate patentability. See *In re Rouffet*, 149 F.3d 1350 (Fed. Cir. 1998).

Applicants are mindful that evidence of a suggestion, teaching, or motivation to combine prior art references may be found not just in the references themselves, but also in the knowledge of one of ordinary skill in the art, or from the nature of the problem to be solved, although "the suggestion more often comes from the teachings of the pertinent references." *In re Dembiczak*, 175 F.3d at 994, 999 (Fed. Cir. 1999), *citing Rouffet*, 149 F.3d at 1355. Although a reference need not expressly teach that the disclosure contained therein should be combined with another, the reason to combine must nevertheless be "clear and particular." *Winner Intern. Royalty Corp.*

v. Wang, 202 F.3d 1340, 1348-49 (Fed. Cir. 2000), *citing Dembiczak*, 175 F.3d at 999. "Close adherence to this methodology is especially important in the case of less technologically complex inventions, where the very ease with which the invention can be understood may prompt one 'to fall victim to the insidious effect of a hindsight syndrome wherein that which only the inventor taught is used against its teacher.' " *Dembiczak*, 175 F.3d at 999, *quoting W.L. Gore & Assocs., Inc. v. Garlock, Inc.*, 721 F.2d 1540, 1553 (Fed. Cir. 1983).

In this regard, it appears that the second layer (3) of Douchet which the examiner proposes to modify to have a durometer of at least 63 Shore D is in fact not a structural component of the hose (1), but rather is a very thin, *i.e.*, 0.05-0.1 mil, layer which is used an adhesive or "bonding agent" to bond the reinforcement layer (4) to the polyamide core tube (2). [*See*, Douchet, at col. 2, ll. 63-65, and at col. 3, ll. 1-5]. Thus, in the Douchet construction, it appears that it is the polyamide core tube (2), and not the bonding agent layer (3), which supports the reinforcement (4). Such a construction appears to be in contrast to that of Gray *et al.* wherein the core tube (12) is specified to have substantial hardness and stiffness to be self-supporting or dimensionally stable. [See, Gray *et al.*, at col. 2, ll. 40-48].

On this basis, Applicants submit that one of ordinary skill in the art following the teachings of Gray *et al.*, would not have been motivated to modify the polyurethane of Douchet in the manner proposed by the examiner. That is, Gray teaches to provide a core tube (12) which is hard and stiff. However, as it is the polyamide core tube (2) of Douchet which appears to support the reinforcement layer (4), there would be seem to be no reason to harden or stiffen the boding agent layer (3).

Of course, it might be assumed that it is always obvious to interchange materials that are known in the art. Such an assumption, however, would bespeak of the impermissible use of hindsight reconstruction to pick and choose among isolated disclosures in the prior art to deprecate the claimed invention. *See In re Fine*, 5 U.S.P.Q.2d 1596, 1600 (Fed. Cir. 1988). Accordingly, Applicants submit that even if the combination proposed by the examiner would have been sufficient to render the claimed invention obvious, there has yet to be articulated a suggestion or other motivation in the prior art or otherwise which would have lead one of ordinary skill in the art to have combined the cited references in the manner proposed.

In addressing Applicants' argument that it would not be obvious to harden the polyurethane bonding agent layer (3) of Douchet because it is a non-structural component of the

hose, the examiner has response that: (1) such layer "is a component of the hose;" and (2) the upper limit of the layer, which according to Douchet is 0.1 mm, "is not significantly smaller than the lower limit, .25mm of the layer of the present invention." As to the former, such argument does seem to assume that it is always obvious to interchanges materials known in the art. As to the latter, Applicants point out that there in fact is no end point overlap as between the Douchet and claimed layers. Indeed, the lower end of the claimed layer is still more than double the thickness of the layer of Douchet, with the upper end of 2.2 mm being more that 20 times the thickness of that layer.

The examiner also has responded that the secondary Gray *et al.* reference has been cited "merely to disclose that it is known that a polyurethane layer can have a shore durometer between about 63 Shore D and 83 Shore D, in order to prevent its displacement into the reinforcement layer applied directly thereto, as is the case in both Douchet and Gray et al." In fact, Douchet does teach at col. 3, ll. 8-11 that, "[i]n some cases, the viscosity of the bonding agent is chosen so as to enable it to pass through the gaps in the filamentary structure 4." In other cases, a "tight reinforcement 4 [does] not allow the bonding agent of the invention to pass through." [col. 3, ll. 11-14]. In either case, a hot melt adhesive is specified, and it is submitted that to modify such layer on any manner suggest by Gray *et al.* or otherwise to be other than as specified in the reference would destroy its intended function as an adhesive. It is well-settled that references are not properly combinable or modifiable if their intended function is destroyed. MPEP § 2143.02, *citing In re Gordon*, 221 U.S.P.Q. 1125, 1127 (Fed. Cir. 1984).

Moreover, unlike Douchet which contemplates that the reinforcement layer (4) be applied to the bonding agent layer (3) while it is still in a molten state to function as an adhesive, Gray *et al.* teaches that core tube (12) is cured prior to the reinforcement being applied. [*See* Douchet, at col. 4, l. 53, bridging col. 5, l. 20]. Accordingly, any teaching which might be gleaned form Douchet regarding the hardness of its core tube (12) would seem to be inapposite as applied to the bonding agent layer (3) of Gray *et al.*

Thus, it is submitted that independent claim 36, as well as dependent claim 37, should be considered to distinguish over the art made of record. Also, it is noted with appreciation that claims 38-40, currently dependent on rejected independent claim 36, have been indicated to constitute allowable subject matter if rewritten in independent form.

Conclusion

As the present claim program has been shown to properly distinguish over the art made of record, Applicants-Appellants respectfully urge the Board to overrule the rejection of the appealed claims and to permit the application to pass to issue.

Respectfully submitted,

Dated: March 05, 2007

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VIII. CLAIMS APPENDIX

36. A tubular polymeric composite member comprising:

a first layer comprising a first thermoplastic selected from the group consisting of polyamides, and copolymers and blends thereof; and

a second layer bonded directly to the first layer comprising a second thermoplastic polymeric selected from the group consisting of polyurethanes, and copolymers and blends thereof,

wherein the second thermoplastic material has a durometer of between about 63 Shore D and 83 Shore D.

37. The composite member of claim 36 wherein the second thermoplastic material has a durometer of between about 70 Shore D and 75 Shore D.

38. The composite member of claim 36 wherein the second thermoplastic material comprises a crystallization retarding component.

39. The composite member of claim 38 wherein the crystallization retarding component is a diol which is branched, substituted, or heteroatom-containing.

40. The composite member of claim 36 wherein the second thermoplastic material has a hard segment content of at least about 20%.

IX. EVIDENCE APPENDIX

1. Douchet, U.S. Patent No. 5,706,865.

Entered into the record in the non-final Office Action mailed October 05, 2005.

2. Gray *et al*, U.S. Patent No. 4,380,252.

Entered into the record in the non-final Office Action mailed October 05, 2005.

US005706865A

United States Patent [19]

Douchet

[11] Patent Number: 5,706,865

[45] Date of Patent: Jan. 13, 1998

[54] **PIPE FOR HIGH PRESSURE FLUID**

[75] Inventor: Jean-Claude Douchet, Le Plessis-Brion, France

[73] Assignee: Nobel Plastiques, Nanterre, France

[21] Appl. No.: 633,736

[22] PCT Filed: Nov. 7, 1994

[86] PCT No.: PCT/FR94/01287

§ 371 Date: Apr. 22, 1996

§ 102(e) Date: Apr. 22, 1996

[87] PCT Pub. No.: WO95/13494

PCT Pub. Date: May 18, 1995

[30] **Foreign Application Priority Data**

Nov. 9, 1993 [FR] France 93 13360

[51] Int. Cl.[6] F16L 11/08

[52] U.S. Cl. 138/125; 138/126; 138/137; 138/141

[58] Field of Search .... 138/137, 123–126, 138/140, 141, DIG. 1, DIG. 7; 428/36.1, 36.2

[56] **References Cited**

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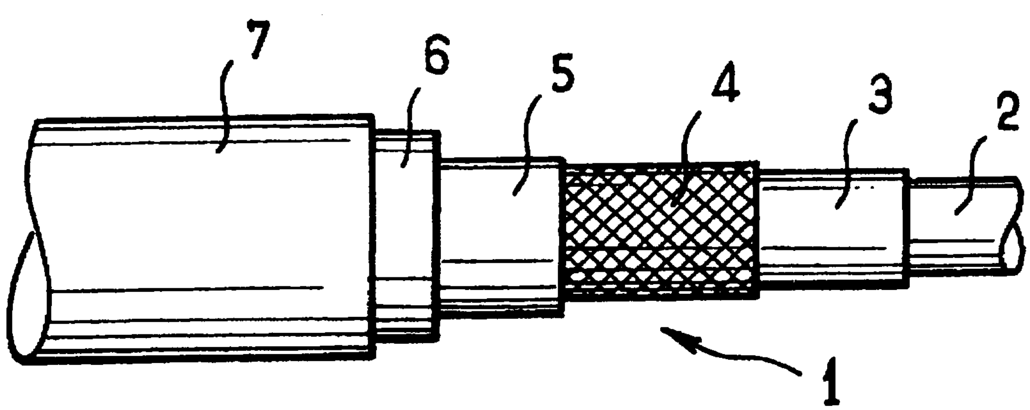
Primary Examiner—Patrick F. Brinson
Attorney, Agent, or Firm—Griffin, Butler, Whisenhunt & Kurtossy

[57] **ABSTRACT**

A pipe comprising a multilayer inner core (1) whose outer layer is made of polyamide or of EVOH to provide an effective barrier function, and outer reinforcement that withstands pressure. The outer reinforcement comprises at least one filamentary reinforcing structure (4) placed around the core (1), a covering outer layer (7), and at least one bonding agent (3, 5) for bonding the reinforcing structure (4) to the inner core (1), the agent being selected from polyurethane or polyamide hot melt adhesives and thermosetting polyesters.

14 Claims, 1 Drawing Sheet



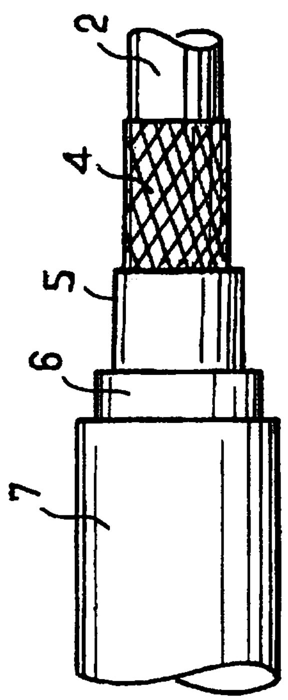


FIG.3

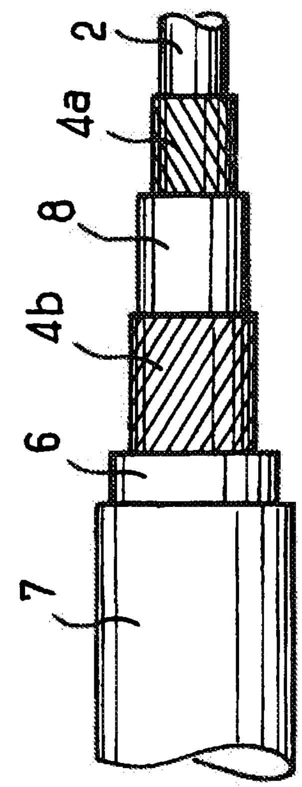


FIG.4

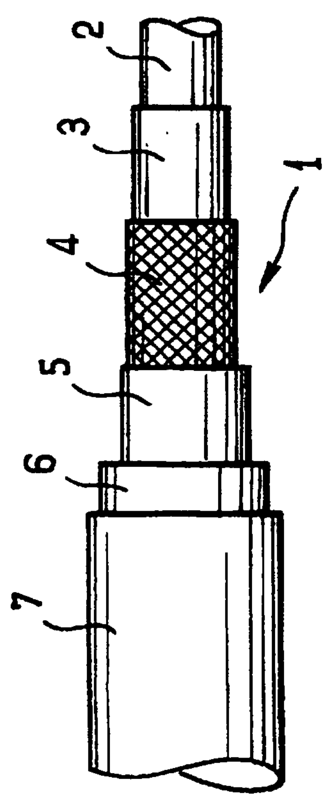


FIG.1

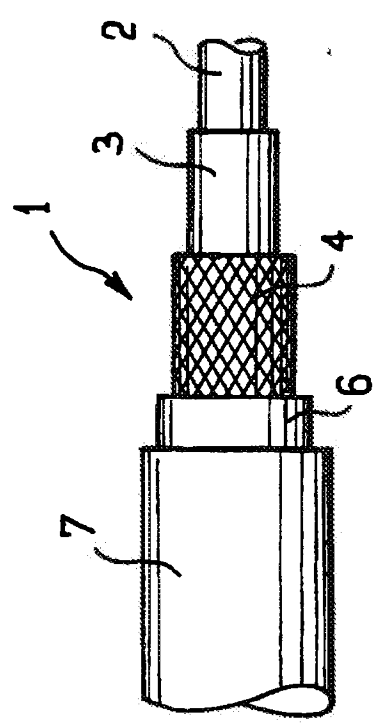


FIG.2

PIPE FOR HIGH PRESSURE FLUID

The present invention relates to a pipe for high pressure fluid, and more particularly for conveying a fluid that changes state, such as a refrigerator fluid.

BACKGROUND OF THE INVENTION

Present pipes for refrigerator fluid such as Freon (in its most recent version known as R134a) are made of multilayer elastomer comprising reinforcement embedded in the rubber and secured to the various layers when vulcanization takes place.

Some such pipes include an inside lining formed by a layer of plastics material such as a polyamide in order to increase the impermeability of the wall relative to the refrigerator fluid being conveyed, whether in the liquid state or in the gas state.

A major drawback of such pipes lies in their weight, their bulk, and their lack of flexibility.

SUMMARY OF THE INVENTION

The present invention seeks to remedy those drawbacks by separating the elements designed to provide a barrier against the refrigerator fluid from the elements for withstanding pressure. The invention thus proposes a pipe having an inner core which performs a multilayer barrier function and an outer portion for withstanding pressure.

The nature of the inner core and particularly the nature of the material forming its outer layer constitutes a constraint on how the outer portion of the pipe can be made. In general, said outer surface is a polyamide to which it is practically impossible to bond a filamentary reinforcing structure. After numerous tests, the invention proposes a specific bond between said inner structure and the filamentary reinforcement which, in addition to being of high quality, and in particular under high temperature and high pressure, also enables the pipe to be made with a relatively thin wall, thereby conferring great flexibility thereto.

To this end, the invention therefore provides a pipe comprising an inner core whose outer structure is made of polyamide that provides an effective barrier function, and outer reinforcement that withstands pressure, the reinforcement comprising a filamentary reinforcing structure such as a weave, a braid, or a knit that is placed around the core, an outer covering layer of thermoplastic rubber based on polyolefin or on polyprobutyl, and at least one agent for ensuring bonding at least between said filamentary structure and the inner core. Given the low degree of compatibility between the outside surface of the core and the nature of the threads used (aromatic polyamides or polyesters), numerous tests were performed to discover that the effective bonding agent had to be either a hot melt polyurethane, or a hot melt polyamide, or else a thermosetting polyester.

Preferably the inner core includes, three layers of polyamide, with the outer layer made from a polyamide elastomer, e.g. a copolyamide elastomer of the type ELY 60 or ELX23NZ, products developed by EMS CHEMIE AG of Zurich, Switzerland. The core is made by coextrusion and constitutes an advantageous solution to the problem of conveying a refrigerator fluid in a flexible pipe while retaining excellent barrier and chemical resistance qualities. It may also incorporate a coextruded layer of EVOH, either between two layers of polyamide or outside said layers.

In a first method, the outer reinforcement is made by extruding hot melt polyamide or polyurethane or thermosetting polyester onto the core and then installing the filamentary structure (wrapped around, weave, braid, or knit made from aromatic polyamide or polyester fibers) and then extruding a second layer of hot melt polyamide or polyurethane or thermosetting polyester thereon preferably with coextrusion of maleic acid to reinforce the bonding with the outer layer of thermoplastic rubber.

In a variant of this method, it suffices to deposit only one layer of bonding agent between the core and the filamentary structure. In another variant, the bonding agent may be placed between the filamentary structure and either the outer layer or the core, providing the viscosity of said bonding agent enables it to be sweated through the filamentary structure to reach the core or the outer layer.

When the filamentary structure is made of tapes of threads wrapped around, it is possible to apply a single layer of bonding agent between two sheets of threads that are wound successively and in opposite directions onto the core.

If a stiffer pipe is required, the thermoplastic rubber may be replaced by a layer of polyamide; under such circumstances, maleic acid is not essential.

In another variant embodiment, a filamentary structure based on fibers that have been preimpregnated with hot melt polyamide or polyurethane or with thermosetting polyester is installed around the central core. The quality of the bonding achieved between the core, the threads, and the outer layer is less good, but the cost is lower, and the bonding may be adequate in certain applications.

Other characteristics and advantages will appear from the following description of an embodiment of the invention given by way of indication.

BRIEF DESCRIPTION OF THE DRAWINGS

Reference is made to the accompanying drawing, in which:

FIG. 1 is a view showing the various layers making up a first embodiment of a pipe of the invention; and

FIGS. 2, 3, and 4 show variants of the FIG. 1 embodiment.

DESCRIPTION OF PREFERRED EMBODIMENTS

The tube 1 shown in FIG. 1 comprises an inner core 2 made up essentially from a plurality of polyamide layers, e.g. three such layers, namely an inner layer of polyamide 12 that is about 0.35 mm thick, an intermediate layer of polyamide elastomer that is about 0.2 mm thick, and an outer layer of polyamide 6 that is 0.45 mm thick, the core being formed by coextrusion to constitute a tubular wall having a thickness of about 1 mm.

Thereafter, the pipe of the invention comprises a layer 3 of hot melt polyamide, or of hot melt polyurethane, or of thermosetting polyester extruded onto the inner core, with a cover, a braid, or a knit of fibers 4 being put into place thereon, where the fibers may be made of polyester or of aromatic polyamide such as Kevlar (registered trademark).

The layer 5 is identical to the layer 3, i.e. it is a layer of hot melt polyamide or polyurethane or of thermosetting polyester covered by coextrusion in a layer of maleic acid 6 which enhances bonding of the intermediate layers to the outer layer 7 made of a thermoplastic rubber based on polyolefin or on polyprobutyl. The thickness of the layers 3 and 5 is about five-hundredths of a millimeter to one-tenth of a millimeter. The thickness of the layer 7 lies in the range 1 mm to 2 mm. The layer of maleic acid is a few hundredths of a millimeter thick.

The advantage of using bonding agents such as hot melt polyurethane or polyamide or thermosetting polyester should be observed: they provide good strength and good performance at temperatures (150° C. to 200° C.) much greater than those of solvent-based adhesives.

FIG. 2 shows a variant embodiment of a pipe of the invention. The layer 5 of bonding agent is omitted, so there is only one layer 3. In some cases, the viscosity of the bonding agent is chosen so as to enable it to pass through the gaps in the filamentary structure 4 so as to reach the outer layer 7, if necessary via the layer of maleic acid 6. More precisely, the composition is given below of a pipe made with a single layer 3 and with tight reinforcement 4 that did not allow the bonding agent of the invention to pass through. The composition gave satisfaction in that it retained its mechanical and barrier qualities under a pressure of 35 bars and a temperature of 135° C. Thus, the multilayer inner core comprised an outer layer of modified polyamide BLX23NZ manufactured by the Swiss firm EMS CHEMIE AG, the bonding agent between the inner core and the reinforcement being a cross-linkable polyurethane adhesive reference Perfect 254 or 413 from NATIONAL STARK, the reinforcing layer was made of 1440 dtex polyester threads of DIOLEN 855T from AKZO, the adhesive agent between said reinforcement and the outer layer of thermoplastic elastomer was a maleic acid product having the reference PO 1015 F from EXXON, and the thermoplastic elastomer was of the SANTOPREN type, both EPDM polypropylene (101-64) from AES and butyl polypropylene from DSM being suitable. The adhesive was cross-linked in known manner using hot water.

FIG. 3 shows a variant way of making a pipe of the invention. The layer 3 of bonding agent is omitted leaving only the layer 5 which is of a viscosity that is determined so as to enable it to pass through the gaps in the filamentary structure 4 so as to reach the inner core 2.

Finally, FIG. 4 shows a filamentary structure made by winding two sheets of threads *4a* and *4b* consecutively, with the sheets being wound in opposite directions around the axis of the core. In this case, the bonding agent may be restricted to a single layer 8 that is placed between the two sheets *4a* and *4b* constituting a weave, with the bonding agent sweating through at least to the core.

In a variant embodiment of the pipe, the layers 3 and 5 are omitted and the woven or braided textile reinforcement 4 is directly impregnated with the hot melt substances. Bonding is then naturally limited to the points of contact between the reinforcement 4 and the inner core 2 or the outer layer 7, with maleic acid 6 being added for this outer bonding.

In certain applications, it may be preferable to have an outer layer of polyamide, thereby imparting greater stiffness to the pipe, with maleic acid being unnecessary between the hot melt polyurethane (or polyamide) and the outer layer.

Finally, the structure of the inner core can be varied by adding a layer of EVOH by coextrusion, where EVOH is a substance known per se and known for its effectiveness as a barrier against certain components of gasoline. The EVOH layer may be placed outside the multilayer polyamide and the measures of the invention apply since it has the same difficulties of compatibility and bonding with a filamentary

reinforcing structure and with a flexible outer layer of butylpolypropylene or thermoplastic rubber.

The invention makes it possible to obtain pipes that are light in weight and small in diameter, possessing good performance with respect to constituting a barrier and to withstanding pressure (35 bars) and temperature (135° C.).

I claim:

1. A pipe comprising an inner core whose outer surface is made of polyamide, and outer reinforcement that withstands pressure, wherein the outer reinforcement comprises at least one filamentary reinforcing structure placed around the inner core, a covering outer layer, and at least one bonding agent for bonding the reinforcing structure to the inner core, the bonding agent being selected from the group consisting of polyurethane, polyamide hot melt adhesives and thermosetting polyesters.

2. A pipe according to claim 1, wherein the bonding agent is a hot melt polyurethane.

3. A pipe according to claim 2, wherein said filamentary reinforcing structure is bonded to said covering outer layer by a second bonding agent including hot melt polyurethane.

4. A pipe according to claim 1, wherein the bonding agent is a hot melt polyamide.

5. A pipe according to claim 4 wherein said filamentary reinforcing structure is bonded to said covering outer layer by a second bonding agent including hot melt polyamide.

6. A pipe according to claim 3, wherein a layer of maleic acid is included between said second bonding agent and said covering outer layer.

7. A pipe according to claim 1, including a second bonding agent for bonding the filamentary structure to the covering outer layer which second bonding agent includes a layer of maleic acid.

8. A pipe comprising an inner core whose outer surface is made of EVOH, and outer reinforcement that withstands pressure, wherein the outer reinforcement comprises at least one filamentary reinforcing structure placed around the inner core, a covering outer layer, and at least one bonding agent for bonding the reinforcing structure to the inner core, the bonding agent being selected from the group consisting of polyurethane, polyamide hot melt adhesives and thermosetting polyesters.

9. A pipe according to claim 8, wherein the bonding agent is a hot melt polyurethane.

10. A pipe according to claim 9, wherein said filamentary reinforcing structure is bonded to said covering outer layer by a second bonding agent including hot melt polyurethane.

11. A pipe according to claim 8, wherein the bonding agent is a hot melt polyamide.

12. A pipe according to claim 11, wherein said filamentary reinforcing structure is bonded to said covering outer layer by a second bonding agent including hot melt polyamide.

13. A pipe according to claim 10, wherein a layer of maleic acid is included between said second bonding agent and said covering outer layer.

14. A pipe according to claim 8, including a second bonding agent for bonding the filamentary structure to the covering outer layer which second bonding agent includes a layer of maleic acid.

* * * * *

United States Patent [19]

Gray et al.

Best Available Copy

[11] **4,380,252**

[45] **Apr. 19, 1983**

[54] **WIRE REINFORCED HOSE AND METHOD**

[75] Inventors: **Herbert W. Gray**, Lawson; **Roger A. Payne**, Excelsior Springs, both of Mo.

[73] Assignee: **The Gates Rubber Company**, Denver, Colo.

[21] Appl. No.: **246,516**

[22] Filed: **Mar. 23, 1981**

[51] Int. Cl.^{3} **F16L 11/08**; B32B 5/20

[52] U.S. Cl. **138/125**; 138/132; 138/DIG. 9; 156/79

[58] Field of Search .... 138/125, 127, 133, 149, 138/DIG. 9, 144, DIG. 1, 132, 137, 138, 139, 138/141, 174, DIG. 7; 156/149, 79; 174/101.5; 174/110 F

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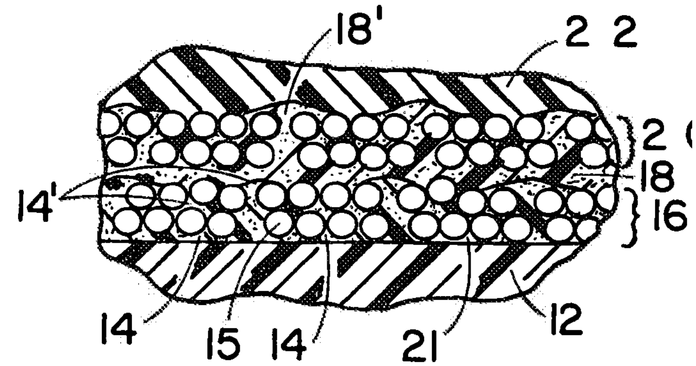
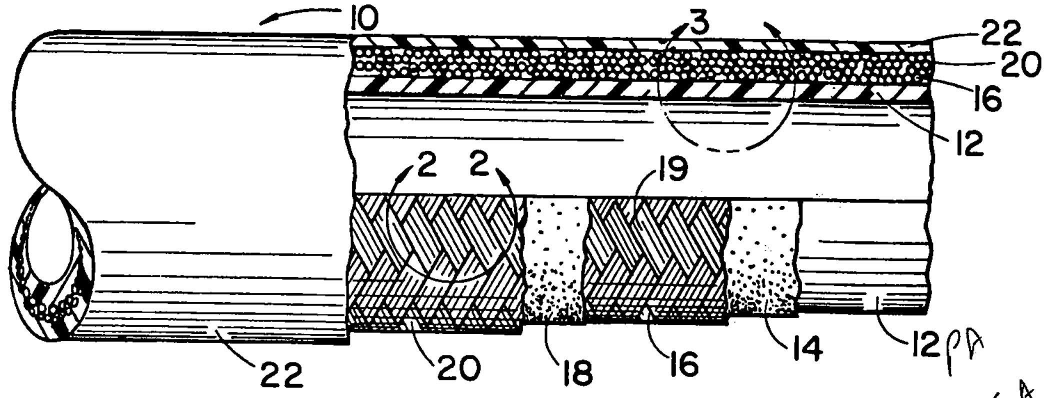
[57] **ABSTRACT**

A hose of improved impulse life is described including an inner polymeric tube which has a relatively hard outer surface, a tightly packed wire reinforcement e.g., braid or spiral, telescoped over the tube, and an expanded polymeric cushion matrix encapsulating at least a portion of the strands of the reinforcement and also promoting wire-to-wire and tube-to-wire adhesion. A method for producing the hose employing a foamable material applicator is also disclosed.

20 Claims, 7 Drawing Figures





PA
75A -63D

FIG. 1

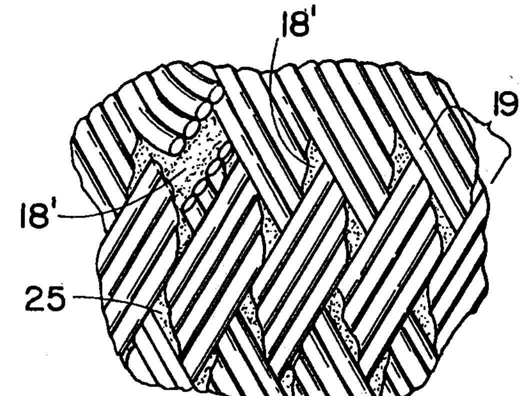


FIG. 2

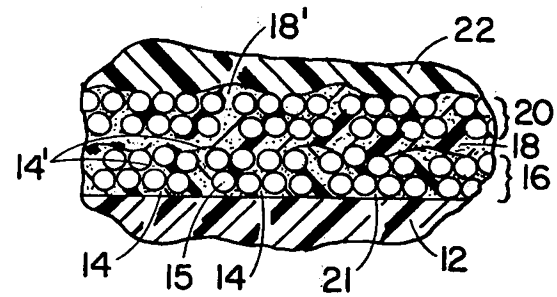


FIG. 3

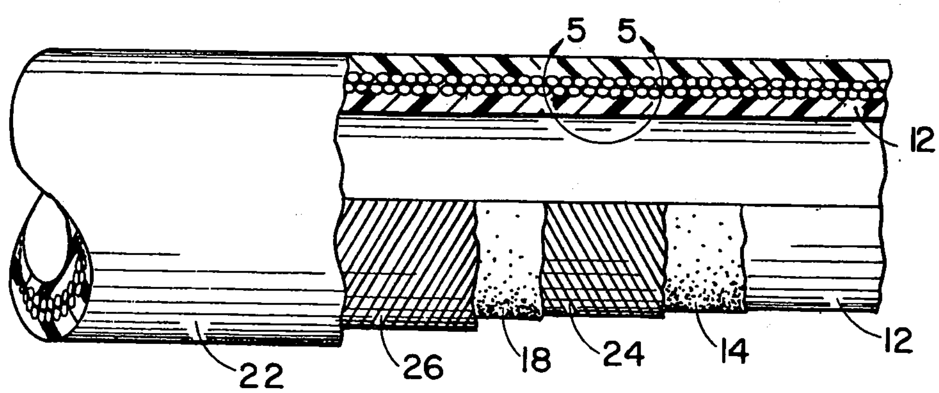


FIG. 4

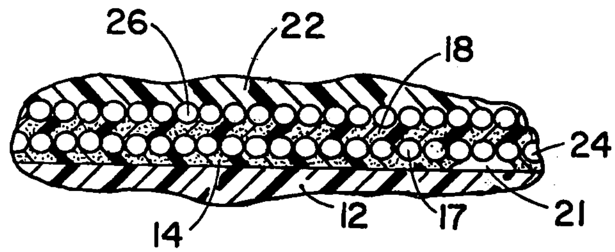


FIG. 5

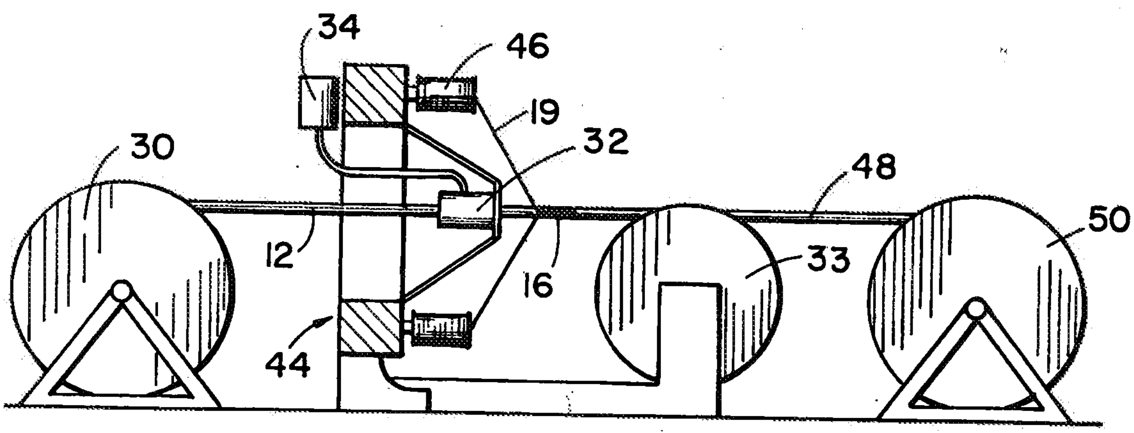


FIG. 6

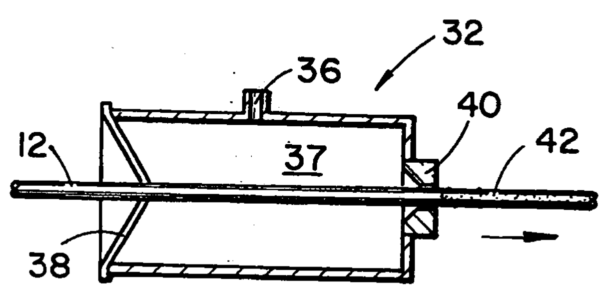


FIG. 7

WIRE REINFORCED HOSE AND METHOD

BACKGROUND OF THE INVENTION

This invention relates to wire reinforced hose articles, more particularly high pressure thermoplastic hydraulic hose and the like, and methods for their production.

Thermoplastic wire reinforced hose is widely used for hydraulic and other high pressure applications. This hose is generally constructed of a pre-cured or set thermoplastic tube which has substantial dimensional stability and a hard outer surface, onto which is telescoped one or more wire braid layers, and an outer protective cover. It is known that the kink resistance of wire or textile reinforced hydraulic thermoplastic hose can be improved by employing an adhesive between the tube and braid and/or between multiple braid layers, however, this practice has not been known to significantly improve impulse life of the hose. Even with the use of polymeric adhesives, impulse life of wire reinforced hose is oftentimes substantially less than required for many applications, apparently because individual wire strands of a beam of the braid during impulsing tend to abrade and/or fret as the wires rub and pantograph together. This causes premature wire fatigue.

It is a primary object of this invention to provide a wire reinforced polymeric hose with improved life principally by reducing wire fatigue, and to a method for producing a hose construction which in operation is characterized by reduced wire fatigue and longer impulse life. It is another object to provide wire reinforced thermoplastic high pressure hose, e.g., hydraulic hose, of significantly improved impulse life while also exhibiting excellent resistance to kink.

SUMMARY OF THE INVENTION

Briefly described, in one form the invention pertains to a hose including an inner polymeric tube, a tightly packed stranded wire reinforcement in the form of one or more layers telescoped over the tube, and an expanded polymeric cushion matrix (e.g., plastic foam) at least partially encapsulating strands of the reinforcement and filling at least a portion of interspaces between adjacent strands.

In a more limited form, the invention is directed to a hydraulic thermoplastic hose including a thermoplastic tube of at least about 75 (Shore A) durometer with a maximum internal diameter of about 2 inches; at least one wire braid reinforcement layer telescoped over the tube and free from embedment in the outer surface of the tube, the beams of the braid formed of multiple strands of wire positioned in substantial adjacent contact with one another; a closed cell adhesive foam matrix at least partially encapsulating the wires of the braid, and interposed and bonded between at least a portion of overlapping beams, and penetrating the outer surface of the braid via passageways at areas of intersection between the beams; and a cover telescoped over the braid reinforcement.

The invention also comphehends a method for producing wire-reinforced hose by the steps of (a) forming a self-supporting polymeric tube; (b) applying a coating of an expandable polymeric material onto the outer surface of the tube; (c) twining a tightly packed sheath of stranded wire reinforcement over the coated tube, interspaces being defined between the reinforcement and tube and between individual strands of the reinforcement; and (d) expanding the polymeric material into a cellular cushion matrix at least partially filling said interspaces.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be more particularly described in its preferred embodiments by reference to the accompanying drawings in which like numerals designate like parts, and in which:

FIG. 1 depicts in partial cutaway, and in partial section a hose in accordance with the invention;

FIG. 2 is an enlarged partial view along 2—2 of FIG. 1, looking at the outer surface of the outermost braid reinforcement layer;

FIG. 3 is an enlarged view taken along 3—3 of FIG. 1, shown in partial, schematic cross section;

FIG. 4 is a view similar to FIG. 1 showing an alternative hose construction made in accordance with the invention;

FIG. 5 is a partial, schematic sectional view along 5—5 of FIG. 4;

FIG. 6 is a schematic illustration of apparatus employed for partially constructing the hose of the invention; and

FIG. 7 is an enlarged, sectional view of the applicator for applying the expandable polymeric matrix to the hose tube.

PREFERRED EMBODIMENTS OF THE INVENTION

Referring first to FIG. 1, there is shown generally at 10 a cylindrically shaped hose in accordance with the invention, having a cylindrical core tube 12, a layer 14 representing a portion of the expanded polymeric cushion matrix, a first wire reinforcement layer 16 telescoped thereover, optional second layers of cushion matrix 18 and telescoped wire reinforcement 20, and an outer protective sheath or cover 22.

The tube 12 which is formed of a polymeric material is generally dimensionally stable or self-supporting such that it has substantial hardness and stiffness (modulus) at its outer surface, so that it does not flow or displace substantially into the vacant spaces formed along the undersurface of reinforcement layer 16. Preferably the tube has a durometer of from about 75 (Shore A) to about 63 (Shore D), more preferably from about 90 (Shore A) to about 55 (Shore D). These vacant spaces between the tube and undersurface of the braid pattern are shown in FIG. 3 as the interspace occupied by the innermost layer 14 of the expanded cushion matrix which, according to the method of the invention, is applied to occupy such interspace.

While the tube materials will be chosen to meet the specific end application, preferably polymeric materials are chosen from thermoplastic or rubber-like materials such as polyamid, polyester (e.g., Hytrel, a trademark of the Dupont Company), polyurethane, pre-cured natural or synthetic rubbers, and the like. Materials which normally do not have sufficient hardness or stiffness, such as certain grades of polyvinylchloride, uncured rubbers and the like may be employed if they have been compounded or treated to achieve sufficient stiffness or green strength to accept the wire reinforcement without substantial neckdown or other permanent deformation of the tube. Of course, certain softer materials can be employed if they are rendered temporarily hard,

such as by freezing or otherwise treating the surface to increase the apparent modulus of the tube.

Although the invention provides benefits for hose of various dimensions, it has been found that impulse life is significantly improved (versus controls) in hoses of relatively small diameter, generally less than about one inch I.D. (inside diameter) and more particularly less than about ⅜ inch I.D. This advantage for smaller hose sizes is believed to result from the role the expanded matrix takes in cushioning the wire strands and beams subjected to maximum bending stresses.

The wire reinforcement is formed of one or more telescoping layers formed over the tube. Typical configurations of stranded wire reinforcement contemplated by the invention include braid layers **16, 20** of FIG. **1**, and spiral layers (of opposite hand) **24, 26** shown in FIG. **4**, usually applied at the locked angle of about 54°. In either case the individual wire strands are tightly packed, meaning that individual wire strands **15, 17** are generally in adjacent substantial mutual contact with one another. However, some interstitial spacing within the reinforcement pack can be tolerated including, of course, the spacing resulting from overlap of individual beams **19** of the braid pattern, as well as minimal strand-to-strand spacing up to a few strand diameters. Typical braid patterns have beams consisting of from 12 to 1 ends (strands) per beam (also referred to as "per carrier" of the braiding machine). Wire strand diameters are typically from about 0.010 to about 0.015 inches but vary depending upon the hose diameter. The strands may be treated with adhesive to enhance bonding.

In accordance with the invention, the strands of the wire reinforcement sheaths or layers are at least partially encapsulated in a matrix **14, 14', 18, 18'** of expanded polymeric material. By expanded is meant, in the usual sense of the term, that the polymeric material has, during processing, undergone a substantial increase in volume. This is usually effected by a foaming reaction in which an intercellular structure is formed. Most preferred are closed cell foams having a density preferably from about 0.75 to about 1.20, more preferably from about 0.85 to about 0.95 grams/cc of foam. Typical methods of generating the foam include incorporation of a foaming agent which liberates a foaming gas, e.g., CO_2 upon a change in pressure or temperature of the polymeric material incorporating the foaming agent, absorption of a material from the environment which triggers a foaming or expanding reaction, or any other known process.

The polymeric cushion or foam matrix at least partially fills interspaces between adjacent strands **15, 17** of the reinforcement layers, as well as interspaces existing between the overlapping beams **19** in a braid pattern and also between respective reinforcement sheaths if multiple sheaths are employed (such as between braid sheaths, **16** and **20**, and between spiral layers **24, 26**). Because the individual strands **15, 17** are generally circular in cross section, even adjoining strands which are in direct contact will define at the nip adjacent their point of mutual contact an interspace which the expanded polymeric matrix occupies.

The polymeric expanded matrix **14, 14', 18, 18'** of the invention serves a number of important purposes. In one respect, it serves as an adhesive which bonds the tube to the reinforcement layers and/or cover. Most importantly, the expanded polymeric matrix or foam provides a cushioning effect between individual strands **15, 17,** whether situated in a spiral layer or common beam of the braid, or between overlapping or adjacent layers or beams. The cushioning effect is also important when multiple sheaths of reinforcement are employed as at **20, 26**; a cushion **18** is provided between the respective sheaths to reduce abrasion therebetween and the tendency of individual strands otherwise to fret. This all translates into a substantially increased impulse life for the hose. The adhesive nature of the foam matrix also improves greatly the kink resistance of the hose, i.e., reduces the minimum bend radius at which the hose kinks.

It is preferred that the expanded polymeric matrix substantially fills all the interspaces between individual wire strands and between overlapping beams or telescoping sheaths of reinforcement layer. However, some unfilled voids **21** may be present generally without appreciably compromising the effect provided by the expanded matrix. Depending upon the particular application and pressures experienced by the hose, duty cycle differential, pressure cycle, and the like, more or less porosity may be tolerated in the cushion matrix.

The matrix of expanded material also need not be uniform, although uniformity improves hose operation. As seen best in FIG. **2**, the outermost braid of the hose in FIG. **1**, broken apart for illustration, will generally have a layer **18'** of expanded polymeric material in between overlapping beams **19**. At points of intersection between beams, such as at **25**, the expanded material may penetrate the outer surface of the braid and form a nodule or glob, also denoted **18'**. A corresponding hump or glob **14'** may be present on the innermost reinforcement sheath **16**, as well. These masses of material do not adversely affect the quality of the hose and in fact promote more extensive encapsulation of the individual strands. Particularly at the intersection points **25** of the braid beams, they tend to serve as cushions or resilient masses which reduce fretting and abrasion during impulsing and pantographing of the hose in operation.

The outermost reinforcement sheath **20, 26** may be enshrouded by a protective cover **22** of material selected to satisfy the particular application, but most importantly to protect the outermost reinforcement layer. Any desired polymeric material such as thermoplastic or rubber materials, including natural and synthetic rubbers, polyvinylchloride, polyurethane, polyamid, polyester and the like, may be used. Normally it is preferred to employ thermoplastic cover materials which are self-curing. An additional layer of cushion matrix may also be applied over the outermost reinforcement layer and beneath the cover **22**.

The method of construction of the hose of FIG. **1** is illustrated in FIGS. **6** and **7**. Core tube **12** may be extruded from a standard extruder (not shown), and stored on reel **30**. The tube is then let off from reel **30** and pulled through polymeric applicator **31**, the tension of which is controlled by capstan **33**. The applicator **32**, shown more clearly in FIG. **7**, is of the wiping die type including a central chamber **37** which is supplied with expandable adhesive in liquid form from supply tank **34** through a connecting line via inlet **36**. The tube passes through a plastic seal **38**, into chamber **37** filled with the expandable adhesive, and exits through wiping die **40** carrying a relatively thin coat **42** of expandable adhesive on its outer circumference in accordance with the invention. Preferably, for most applications the coating **42** should be thick enough to promote the subsequent

foaming action and therefore is preferably greater than about 0.005 inches thick. To achieve optimum coating thickness it is preferred that the adhesive supply in chamber 37 have a viscosity nearly that of molasses, in general preferably from about 6,000 to about 80,000 centipoises, as measured on a Brooksfield viscosimeter.

Rather than wiping the tube through a die opening, alternatively other means may be employed to apply the coating, either continuously or discontinuously, onto the tube outer surface. Thus, the tube could be dipped into a tank containing the expandable adhesive, the material brushed or sprayed onto the surface, or the like.

On to the thus coated tube is twined a tightly packed sheath of stranded wire reinforcement. In the example of FIG. 6, braider deck **44** of conventional design including a plurality of braider carriers **46** applies overlapping beams **19** of a plurality of individual wire strands **15** onto the coated tube to form a braided sheath layer **16**.

In the most preferred embodiment, the expandable adhesive is formed of a polymeric material which, upon exposure to ambient air, undergoes chemical reaction whereby the adhesive expands into a cellular structure which penetrates interspaces existing in the braid pack as hereinbefore defined, tending to at least partially encapsulate individual strands **15** of the wire reinforcement. A class of materials which has been found to satisfy this criteria are the moisture cure polyurethanes which include a reactive polyurethane prepolymer which reacts with moisture contained in the ambient air (higher humidities preferred) and undergoes the foaming reaction whereby CO_2 is released. A linear, thermoplastic (non-cross-linked) closed cell urethane cushion matrix **14** is simultaneously formed. As shown in FIGS. 2 and 3, some of the moisture cure polymeric material may ooze through interstices formed between adjoining and overlapping beams **19** to form globules or layers **14'**, (**18'**) at the outer surface of the braid. In this preferred embodiment, the braided, coated tube **48** is wound up on reel **50** and stored in ambient air for a period sufficient to permit the moisture cure urethane to undergo expansion. This period of time may typically be from about 12 to about 24 hours.

As the expansion reaction takes place, the urethane matrix or foam swells and places the wire sheath **16, 24** in slight tension, which tightens the braid and tends to orient it in the preferred lock angle, and immobilizes it so that it has less chance to flex during further processing. The resultant hose with tube and wire reinforcement at least partially encapsulated in the expanded cushion matrix may be employed directly as a hose, or more preferably is provided with an outer protective cover **22**, such as by a standard extrusion operation (not shown).

Alternatively, the expansion of the polymeric adhesive may be provided by the inclusion of a standard foaming agent, which may be activated to release the foaming gas by heating the reinforced tube in an oven (not shown), by pressure control, or by other means. The foaming takes place after the reinforcement sheath is in place telescoped over the tube, to thereby fill interspaces between wire strands and place the wire reinforcement sheath in tension, as previously described with respect to moisture cure urethanes.

Various expandable polymeric materials can be used in addition to the moisture cure urethanes (or other materials which cure by absorption of moisture or other material from the ambient air). The particular choice of expandable polymeric material will be dictated by the tube material, it being preferred that the expanded cushion matrix forms a bond between the wire reinforcement and the tube and/or the cover. Of course, using either the moisture cure polymeric materials or polymeric materials blended with foaming agents, one can add catalysts to speed the reaction with the moisture in the air, speed up the foaming reaction by releasing the foaming agents in situ by external heating, or the like.

As a specific example illustrating the invention and drawing comparisons against controls, the following is provided.

EXAMPLE

Two groups of three hoses each were constructed and tested against SAE 100R1 specification in accordance with the procedures of SAE J343. All six hose replications were ⅜ inch I.D. employing Hytrel (trademark) tubes of about 0.035 inch wall gauge, a single wire braid of 8 ends per beam of 0.010 inch gauge brass coated wire strands tightly packed and telescoped over the tubes, and an outer cover of about 0.030 inch wall gauge formed of Santoprene (a trademark of Monsanto Company identifying a cross-linked copolymer of EPDM and propylene). The Group I hoses also employed an expanded urethane cushion matrix in accordance with the invention, applied as a single uniform coating layer of about 0.005 inches thickness over the Hytrel tube per the procedure discussed in respect to FIGS. 6 and 7. The coating material used was Chempol 35-0014, a moisture cure polyurethane prepolymer having a free isocyanate content of from 7-10 weight percent manufactured by Freeman Corporation.

After the coating was applied to the tube and the braid applied over the coated tube, the braided hose was stored for 18 hours at about 25 percent relative humidity, during which time the expansion reaction took place and the cushion matrix formed as previously discussed. Thereafter, the Santoprene cover was applied over a braid and cushion matrix resembling that shown in FIG. 2. The hose was set at this point, requiring no additional curing step.

The Group II hoses represented the controls which were identical with the Group I hoses with the exception that no adhesive/cushion matrix was employed.

The ends of the hoses were fitted with standard hydraulic couplings having a ferrule crimp O.D. (outside diameter) of 0.67 inches, and a crimp length of 1 inch. The coupled hoses were made to assume a curve defined by a 5 inch bend radius. The temperature was held at 250° F. and the hoses impulsed at 2812 p.s.i.

The hoses of both Group I and Group II had test burst pressures of from 13,000-13,500 p.s.i., and equivalent length, O.D. and twist changes (if any) at 2250 p.s.i.

Each of the three hose samples of Group I endured 557,307 impulse cycles without failure, the testing having been discontinued at that point. Each of the three control samples of Group II sustained hose body failures respectively at 51,044, 69,137 and 110,557 impulse cycles, dramatically evidencing superior impulse lives for the Group I samples of the invention, which passed SAE 100R1 performance specifications.

Similar tests were performed on hoses having 1 inch I.D.'s. Both the hoses of the invention and the controls were removed from the test with the same number of impulse test cycles, prior to failure.

Similar tests were also performed except the $\frac{3}{8}$" I.D. hose samples were reinforced with aramid fiber braid instead of wire braid. The hoses using the polymeric cushion matrix and the controls performed substantially the same.

While certain representative embodiments and details have been shown for the purpose of illustrating the invention, it will be apparent to those skilled in this art that various changes and modifications may be made therein without departing from the spirit or scope of the invention.

What is claimed is:

1. A hose comprising an inner polymeric tube, a substantially tightly packed stranded wire reinforcement telescoped thereover, and an expanded polymeric cushion matrix at least partially encapsulating strands of the reinforcement and filling at least a portion of interspaces between adjacent strands and filling at least a portion of interspaces between the reinforcement and the polymeric tube.

2. The hose of claim **1** wherein the polymeric cushion matrix fills substantially all the interspaces between adjacent strands.

3. The hose of claim **1** wherein the reinforcement is in the form of wire braid, a portion of the expanded polymeric cushion matrix being interposed between overlapping beams of the braid.

4. The hose of claim **1** wherein the reinforcement is formed of multiple telescoped annular layers, a portion of the expanded polymeric cushion matrix being interposed between such annular layers.

5. A hose comprising an inner thermoplastic tube having a durometer of at least about 75 (Shore A), a tightly packed stranded wire reinforcement telescoped thereover, and an expanded cellular polymeric cushion matrix positioned between the tube and reinforcement and filling at least a portion of interspaces between adjacent strands of the reinforcement.

6. The hose of claim **5** having an outer protective cover positioned over the reinforcement/cushion matrix.

7. The hose of claim **5** wherein the cushion matrix is a closed cell foam having a density of from about 0.75 to about 1.20 grams/cc of foam.

8. The hose of claim **5** wherein the cushion matrix is formed of a moisture cure prepolymer.

9. A kink-resistant high pressure hose comprising:

an inner thermoplastic tube having a durometer of at least about 75 (Shore A);

at least one wire braid reinforcement layer telescoped over the tube and whose beams are composed of wire strands positioned closely adjacent one another;

a polymeric foam layer interposed between the tube and undersurface of the braid reinforcement layer and at least partially filling interspaces between overlapping beams and between adjacent strands of a beam; and

a cover positioned over the braid reinforcement.

10. The hose of claim **9** wherein the foam layer forms a bond with the tube.

11. The hose of claim **9** wherein the cushion matrix is a closed cell foam having a density of from about 0.75 to about 1.20 grams/cc of foam.

12. The hose of claim **9** wherein the cushion matrix is formed of a moisture cure urethane.

13. A hydraulic thermoplastic hose comprising:

a thermoplastic tube of at least about 75 (Shore A) durometer with a maximum internal diameter of about 2 inches;

at least one wire braid reinforcement layer telescoped over the tube and free from embedment in the outer surface of the tube, the beams of the braid formed of multiple strands of wire positioned in substantial adjacent contact with one another;

an adhesive foam matrix at least partially encapsulating wires of the braid, and interposed and bonded between at least a portion of overlapping beams, and penetrating the outer surface of the braid via passageways at areas of intersection between beams; and

a cover telescoped over the braid reinforcement.

14. The hose of claim **13** wherein the reinforcement is formed of multiple telescoped annular layers, a portion of the expanded cushion matrix being interposed between such annular layers.

15. The hose of claim **13** wherein the cushion matrix is a closed cell foam having a density of from about 0.75 to about 1.20 grams/cc of foam.

16. The hose of claim **13** wherein the cushion matrix is formed of a moisture cure urethane.

17. A hose comprising an inner polymeric core tube, a substantially tightly packed wire braid reinforcement telescoped thereover, the braid being formed of overlapped beams formed of multiple strands of wire, and an expanded polymeric cushion matrix at least partially encapsulating strands of the reinforcement, filling at least a portion of interspaces between adjacent strands of each beam, and being interposed between overlapping beams of the braid layer.

18. The hose of claim **17** wherein multiple braid layers are employed, and the expanded polymeric cushion matrix fills at least a portion of the space between such multiple braid layers.

19. A hose comprising an inner polymeric tube, a plurality of telescoped annular reinforcement layers formed thereover, one of said annular reinforcement layers being formed of tightly packed wire strands, and an expanded polymeric cushion matrix at least partially encapsulating strands of said one annular reinforcement layer, filling at least a portion of interspaces between adjacent strands, and a portion of the expanded polymeric cushion matrix being interposed between such said plurality of annular reinforcement layers.

20. The hose of claim **19** wherein the polymeric cushion matrix fills substantially all of said interspaces between adjacent strands.

* * * * *

X. RELATED PROCEEDINGS APPENDIX

None